DELINEATING THE JURASSIC TO MID-CRETACEOUS PART OF THE PACIFIC APPARENT POLAR WANDER PATH

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ABSTRACT

The Jurassic to Mid-Cretaceous apparent polar wander path of the Pacific plate irrespective of ages have been delineated. Two poles have been established: one pole, which is relatively older than the other, is at 75.01°N/287.5°E (α_{95} = 6.9°) and the other pole is at 61.0°N°/304.7°E (α_{95} = 4.5°). These results indicate that the Pacific plate drifted southward during the Jurassic to Early-Cretaceous period. Additionally, the results demonstrate that there is an apparent consistent correspondence between changes of plate motion and significant shifts of the Jurassic to Mid-Cretaceous apparent polar wander path.

INTRODUCTION

Apparent polar wander paths (APWP) are one of the primary tools of paleomagnetic research. However, because of the inherent difficulty in obtaining fully oriented samples from beneath the ocean, oceanic plates, including the Pacific plate, until recently did not have well defined APWPs. Consequently, oceanic plates were difficult to include in studies of global tectonics and paleomagnetic field. This problem was solved by the formulation of the seamount paleomagnetism technique (Talwani 1965, Plouff 1976, Parker *et al*. 1987). Following this, Sager and Pringle (1988) using mainly seamount paleomagnetic data delineated a well defined Pacific APWP for Mid-Cretaceous to Present which covers only about half of the lifetime of the Pacific plate. Delineation of the older part of the Pacific APWP has been difficulty due to the scarcity of paleomagnetic data of that age, and the fact that among the available data only few have reliable ages. Efforts to improve the defined Pacific APWP as well as extend it into the older past have continued as more reliable data and good technology becomes available (e.g., Sager and Koppers 2000). Sager and Koppers (2000) used 27 paleomagnetic poles from seamounts dated by $^{40}Ar/^{39}Ar$ to revise the Pacific APWP. The new APWP is complex than that of Sager and Pringle (1988) and does not have a sharp bend at 82Ma. Similarly, Sager (2003) computed a new chron C33r pole for the Pacific APWP using basalt and sediment core data from Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP). For the purpose of this work the Pacific APWP of Sager and Pringle (1988) is used mainly because of its simple shape and the fact that this work is dealing with the older unknown part of the APWP.

The importance of a complete defined Pacific APWP cannot be overemphasized. The Pacific plate is known to have a very long and varying tectonic evolution history (Nakanishi *et al*. 1992). This is the largest oceanic plate, covering about 20% of the earth's surface and abuts six major and several minor plates, and thus the key to the understanding of the tectonic evolution of the Pacific basin and adjacent plates. A complete defined Pacific APWP would be a useful benchmark for paleomagnetic research of both the Pacific plate and the adjacent plates. In addition to being useful in unraveling tectonic evolution history of Pacific basin plates, because many Pacific seamounts that gave reliable poles are not dated, the APWP will serve as a bench mark for dating these seamounts by comparing them with it.

An attempt has been made in this work to delineate the Pacific APWP for Jurassic to Mid-Cretaceous Period. The scarcity of paleomagnetic data with reliable dates for Jurassic and Early-Cretaceous Period, calls on any attempt to delineate the APWP for that age to employ methods that do not directly depend on availability of dated paleomagnetic data. Consequently, in this paper a systematic delineation of the Pacific APWP for Jurassic to Mid-Cretaceous Period, which does not depend on availability of dated paleomagnetic data for that period is done.

The data used in this study is a combination of the compilation of Pacific seamount paleomagnetic data with reliable poles of Sager (1992) and Masalu (1994).

METHODS

Because of the scarcity of reliable dates for Jurassic and Early-Cretaceous seamounts, the major inherent difficult for this study is how to isolate seamount poles of that period. This problem was systematically approached as follows. First, from the databases used in this study, only all seamounts on Jurassic seafloor older than M1 (Fig. 1) were selected which gave a total of 59 seamounts (Table 1). It is known that the Jurassic seafloor older than M1 contains Jurassic plus later seamounts. Thus, the selected seamounts gave a scattering of poles from Jurassic and later (Fig. 2). Second, all poles within a distance of the known Mid-Cretaceous to Present Pacific APWP on the right of the dashed line in Fig. 2 traced following the 95% confidence circles of the Pacific APWP of Sager and Koppers (2000) were omitted. Few poles remained on the left of the dashed line which may be due to some errors or it could be the APWP. However, errors are unlikely to put many poles in any one area (i.e., the scatter should be more random). So, the remaining poles are most probably Jurassic to Early-Cretaceous. A mean pole (Fisher 1953) for Jurassic to Early-Cretaceous of the Pacific APWP based on all the isolated/remaining poles (Fig. 2) is at 63.6°N/303.5°E (α_{95} = 5.1°). However, this pole may be misleading because the remaining Jurassic to Early-Cretaceous poles are scattered over a wide area from about 50°N to 75°N. To go around this obstacle the relative ageing of the seamounts was determined by computing their northward drift amounts (Masalu 1994, Masalu *et al*. 1997).

Northward drift is computed as the present latitude of a seamount minus its paleolatitude. Masalu (1994) and Masalu *et al*. (1997) found that Pacific seamounts that are considered older than Mid-Cretaceous display northward drift amounts smaller than those of Mid- to Late-Cretaceous. They suggested that the observation indicates that the seamounts drifted southward when they formed probably during the Jurassic to Early-Cretaceous Period (Larson and Lowrie 1975, Jarrard and Sasajima 1980, Cox and Gordon 1984, Sager and Pringle 1988). The concept of northward drift implies that the smaller the northward drift amounts the older the seamount is (i.e. the more south the seamount drifted). Thus, variations of northward drift amounts of Jurassic to Early-Cretaceous seamounts can give us an idea of their relative age (Masalu 1994). However, the method of analyzing northward drift to investigate relative ageing of seamounts must be used cautiously because in addition to differences in age, the northward drift may also vary depending on the location of the Euler pole of the concerned plate, and erroneous paleomagnetic data. If the Euler pole is far away, then this method works well, but if the Euler pole is very close it can give misleading results. As for this study, the Pacific plate is known to have migrated northward and west-northwestward and to have undergone little rotations (Henderson 1985, Engebretson *et al*. 1985, Duncan and Clague 1985). This implies that the effect of the location of the Euler poles for the Pacific plate will only minimally affect computed northward drift of the seamounts. Nevertheless, it is important to mention here that currently there is resurgence of active research on the absolute motion of the Pacific plate (e.g., Wessel *et al*. 2006, Steinberger *et al*. 2004) following strong evidence for the migration of hotspots (e.g., Duncan *et al*. 2004, Tarduno *et al*. 2003, Tarduno 2007). These new works are poised to change our understanding of the tectonics of the Pacific plate.

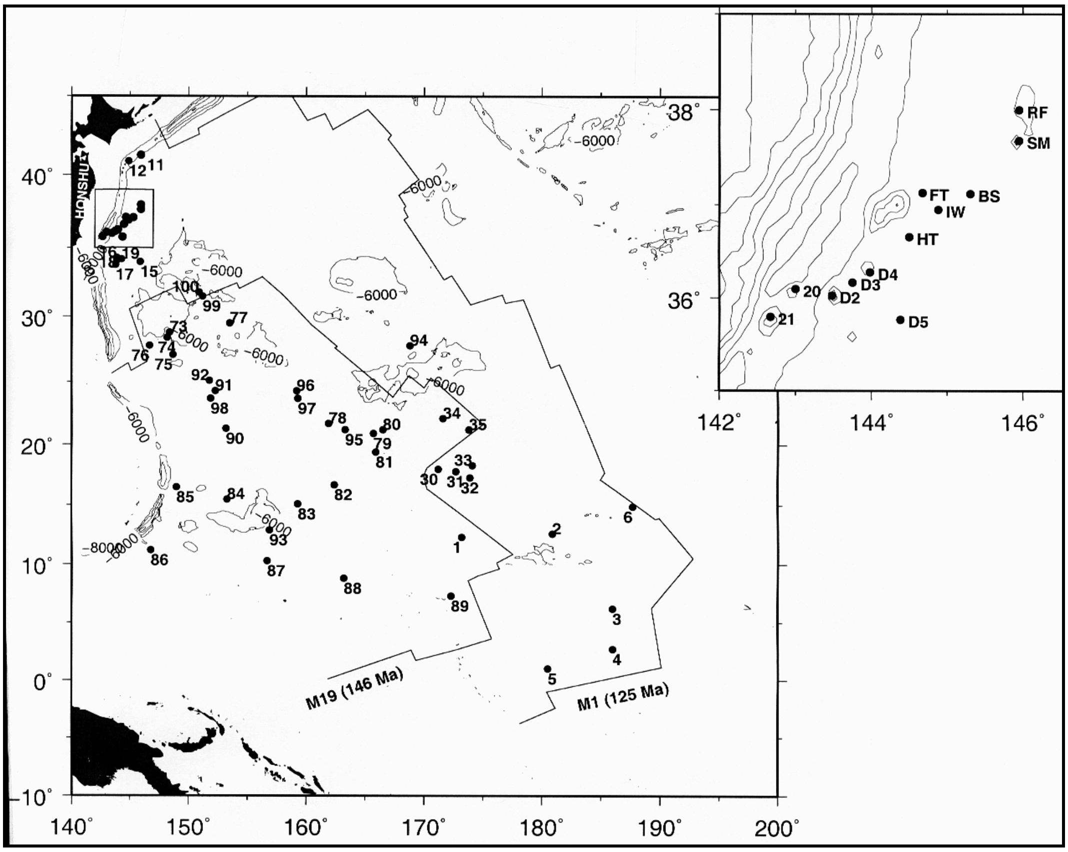

Figure 1: Map of the Pacific Ocean basin showing the locations of seamounts on seafloor older that M1 (123Ma). Insert box as detailed on the top right is the Joban seamount chain. Seamount symbols are as detailed in Table 1.

Table 1: Pacific seamounts on seafloor older than M1.

		Location		Pole				Inten.		Age		Error Ellipse				Reference	
ID	Name	Lat. (°N)	Lon (°E)	Lat. (°N)	Lon (°E)	Inc.	Dec.	U/NU	GRF	Pmag	Other	Maj	Min	Az	Type	Pmag	Age
1	Magnet	12.3	173.2	61	31.2	-20.9	342.3	9.5	3.9	LK					L	1	
2	Dixon	12.6	180.9	68	1	-18.9	0	6.7	5.6	LK					L	2	
3	L1	6.2	186	69.7	27.5	-24.3	352.5	7.1	2.8	LK					L	3	
4	L2	2.7	186	66.5	5.5	37.3	180.2†	7.5	3.8	LK					L	3	
5	L3	1	180.5	54.9	324.1	-45.1	22.4	10.5	4.3	MK					L	3	
6	Unnamed	14.9	187.7	55	1.8	-35.9	3.6	3.8	2	MK	83P				L	4	1
11	Unnamed	41.3	146	49.4	337.1	2.4	352.8	15.6	1.8	MK					L	6	
12	Erimo	40.9	144.9	69	321	36	1	5.8	5.7	EK	130L				L	7	2
13	Ryofu	38	146	53	352.7	2.2	343.2	9.4	3.4						L	6	
				46.2	353.9	-4.3	341.1	7.4/1.2	13	MK		7	2.4	113	S	8	
14	Unnamed	36	143.5	40.9	21.6	7	320	8.3	2.7	K					L	3	
15	Maiko	34	145.9	50.5	327.1	-10.9	359.3	12.2	4.7						L	3	
				53.1	321.1	-5.5	2.9	13.4/4.2		MK		4.7	2.1	113	S	5	
16	Takuyo-Daini	34.3	143.9	75.4	315.7	35.8	2.2	5.0/2.6		EK	>98F	5.6	3	88	S	5	
17	Jenson	33.8	143.8	55	340.5	0.9	350.7	19.4/8.3		MK		5.9	2.6	102	S	5	
18	Jenson N	34.1	143.9	68.6	341.7	25.7	353.3	23.1/9.6		LK		18	8.5	103	S	5	
19	Seiko	34.2	144.3	58.2	328.2	4.9	357.9	11.1/6.8		MK	102A	4.3	1.9	96	S	5	3
20	Katori	36.1	143	59.9	354.1	18.3	344.8	13.9	2.8	MK					L	9	
21	Daiiti-Kashima	35.8	142.7	62.3	348.8	20.1	348	10.7	3.1	MK					L	9	
30	Sio	18	171.2	50.9	277.9	7.7	37.2	3.6	2	EK					L	1	
31	Harvey	17.8	172.7	68.1	21.9	-3	348.5	4.3	2.7	LK					L	1	
32	Thomas	17.3	173.9	73.3	324.2	5.3	8.2	3.5	2.5	EK	165L				L	1	5
33	Allen	18.3	174.1	69.2	328.6	-1.2	8.8	4.1	3.6	EK					L	1	
34	Darwin	22.1	171.6	39.9	316.8	36.2	207.8†	1.9	2.4						L	3	
				43.4	316.6	31.5	205.9†	2.0/0.9		EK	109F	15.5	5.9	55	S	8	6
35	Unnamed	21.2	173.8	84.4	3215	30.6	3.1	2.0/1.4		?		11.1	3.3	52	S	5	
73	Z41	28.8	148.4	55	19	9	334	1.8	2.3	MK					L	10	
74	Z42	28.4	148.2	53	278	5	28	4.2	2.6						L	10	
				59.9	292	6.1	17.2	4.1/1.6	4	EK		7.9	2.7	59	S	8	
75	Z43	27.1	148.7	55.9	323.0	-13.7	3.2	9.2	3.3						L	4	
				57.1	334.1	-11.3	357	8.4/5.1		MK	)3.7K	6.7	2.5	93	S	5	3
76	Z44	27.8	146.7	60	306	-1	11	3	1.8	EK					L	10	
77	Makarov	29.5	153.5	63.7	331.3	6.4	1	8.4	3.4						L	3	
				59.2	346.2	-1.3	353.5	8.9/2.1		MK	94A	2.9	0.9	101	S	5	3
78	Miami	21.7	161.9	51.7	341.5	-30.8	0.3	7.5	2.6						L	3	
				58.9	5.9	-12.2	348.1	8.1/4.7		MK		6.5	2.1	116	S	8	
79	Birdseye	20.9	165.7	58.6	342.3	-20.4	1.8	13	8.1	MK					L	1	
80	Woods Hole	21.2	166.5	55.2	349.5	-25.7	358.2	11.2	3.2						L	3	
				53.2	319.7	-23.2	16	8.0/4.4		MK		6.8	2	61	S	5	
81	Unnamed	19.4	165.9	58.4	5.9	-20.3	349.5	6.2	2.2	MK					L	3	
82	Unnamed	16.7	162.4	71	281.3	13.7	16.7	1.6	5.5	EK					L	1	
83	Seascan	15.1	159.3	57	4.8	-27.9	346	8.9	4.2	MK					L	1	
84	Unnamed	15.5	153.3	71.7	246.5	26	18.8	1.8	9.5	?					L	1	
85	Campbell	16.5	149	55	312.9	31.8	189.6†	4.8	2.4	EK	>118P				L	1	
86	Unnamed	11.2	146.8	74.5	6.4	-1.7	350.2	7.5	2.7	ET					L	1	
87	Winchester	10.3	156.7	55.8	296.6	-29.8	22.1	2.8	4.1						L	1	
				55.3	286	-23	26.8	2.7/0.5		EK		8.6	3.2	38	S	8	
88	Heezen	8.8	163.2	57.4	340.3	-41.3	1.7	5.4	3.4	MK					L	1	

89	Von Valtier	7.3	172.3	63.2	2.2	-34.7	355.3	7.4	4.4		80F				L	4	7
				54.2	307.2	-32.7	25.8	7.6/5.5	14	EK		9.5	4.4	43	S	8	
90	Golden Dragon	21.3	153.2	57.3	330.1	-21.9	1.7	4.5	3.7						L	4	
				56.2	337.4	-23.8	357.6	3.4/0.8		MK	95A	5.6	1.9	98	S	5	3
91	Unnamed	24.3	152.3	74.2	276.9	27.7	13.4	3.4	5.5	EK	78A				L	5	3
92	Unnamed	25.1	151.8	46.2	323.7	33.7	185.5†	3.9	5.6	MK	>118P				L	5	
93	Ita Mai Tai	12.9	156.9	48.2	353.9	-45.7	347.3	1.0/6.7		MK	>110F	19.1	10.6	48	S	5	8
94	Guadaloupe	27.8	168.8	62.4	314.6	-8.5	195.1†	2.6/4.4		EK	>118P	16.2	7.3	71	S	5	
95	Wilde	21.2	163.3	61.8	333.1	-13.2	4.9	7.3/3.9		MK	86A	7.1	2.1	82	S	5	3
96	UCSD	24.3	159.2	55.3	338.4	20.3	180.5†	6.9/0.6		MK		9.2	3.7	95	S	5	
97	Scripps	23.7	159.3	62	335.7	-8.5	1.7	6.2	2.2	MK	98A				L	5	3
98	Smt948	23.7	151.9	57.5	329.5	-17.5	1.3	5.1	2.8	MK					L	11	
99	Isakov	31.5	151.2	52.3	331.5	-12.1	-0.2	10.5/3.5		MK	>98F	4.2	1.7	88	S	5	
100	Isakov NW	31.8	150.9	58	311.9	2.4	10	16.1/7.2		EK		9.4	3.4	74	S	5	
RF	Ryofu	38	145.95	46.62	344.62	-7.46	347.27	10.16/2.41	13	MK		6.54	2.71		S	12	
SM	Soma	37.68	145.95	51.39	337.17	-0.77	353.03	6.53/2.15	9.4	MK		5.26	2.66		S	12	
BS	Bosei	37.12	145.3	-25.95	146.33†	45.4	178.95	1.34	1.3	Mk					L	12	
				-50.2	163.12†	2.56	168.7	3.67/2.29	8.5	MK		8.07	3.44		S	12	
1W	Iwaki	36.95	144.88	40.24	287.02	-10.8	28.04	7.05	2.1	EK					L	12	9
				55.78	285.11	17.1	21.35	3.87/5.1	7.5	MK		12	4.69		S	12	
FT	Futaba	37.13	144.67	-39.7	148.92†	24.9	176.64	6.73/0.91	16	MK		8.33	3.05		S	12	
HT	Hitachi	36.66	144.5	56.24	273.86	23.6	26.09	5.2	2.9	EK					L	12	9
				63.04	295.92	23.5	12.83	5.43/1.44	15	MK		9.08	2.3		S	12	
D4	Daiyon	36.28	143.98	38.4	16.16	-2.27	321.74	13.32/7.02	11	MK		6.35	2.79		S	12	
D5	Daigo	35.77	144.38	56.53	317.14	4.99	3.99	11.77/2.53	46	MK		2.51	0.96		S	12	
D3	Daisan	36.17	143.75	52.11	352.42	3.28	342.76	10.41	5.1	MK					L	12	
				53.69	348.3	4.67	345.74	9.84/1.17	61	MK		3.73	1.31		S	12	
D2	Daini	36.03	143.48	55.47	348.93	7.77	345.74	8	4.6	MK					L	12	
				59.98	349.11	16.3	347.36	11.16/3.33	62	MK		5.11	2.58		S	12	

† Indicates reversed polarity

Heading Abbreviations:

Inc., inclination; *Dec.,* declination; *Inten.,* magnetization intensity (U, uniform; NU, nonuniform) units in amperes/meter, *GFR,* goodness-of-fit ratio; *Error Ellipse*, 95% confidence region; *Maj*, major semi-axis length (in degrees) ; *Min*, minor semi-axis length (in degrees); *Az*, azimuth of major semi-axis (degrees clockwise from north).

Type, inverse technique; L, least squares minimization; S, seminorm minimization; *Ref,* reference number (see below)

Age Abbreviations:
Paleomagnetic ages: *ET*, Early Tertiary; *LK,* Late Cretaceous; *MK*, mid-Cretaceous; *EK, Early* Cretaceous-Late Jurassic. *Other* age *types*: *A*, ^{40}Ar-^{39}Ar; K, Potassium-Argon; *F*, Fossil; *L,* Lithospheric flexure; *P*, Magnetic polarity.

Paleomagnetic References:
(1) Sager, 1983; (2) Francheteau et al., 1969; (3) Harrison et al., 1975; (4) Sager and Pringle, 1988; (6) Uyeda and Richards, 1966; (7) Yamazaki, 1988; (8) Hildebrand and Parker, 1987; (9) Ueda, 1985; (10) Vacquier and Uyeda, 1967; (11) Ueda, 1998; (12), Masalu *et al.*, 1997.

Age References:
(1) Sager and Pringle, 1988; (2) Yamazaki, 1988; (3) Ozima et al., 1983; (4) Saito and Ozima, 1977; (5) Watts *et al*., 1980; (6) Harrison *et al*., 1975; (7) J. A. Haggerty, personal communication, 1982; (8) Baltuck *et al*., 1986; (9)Masalu *et al., (*2001).

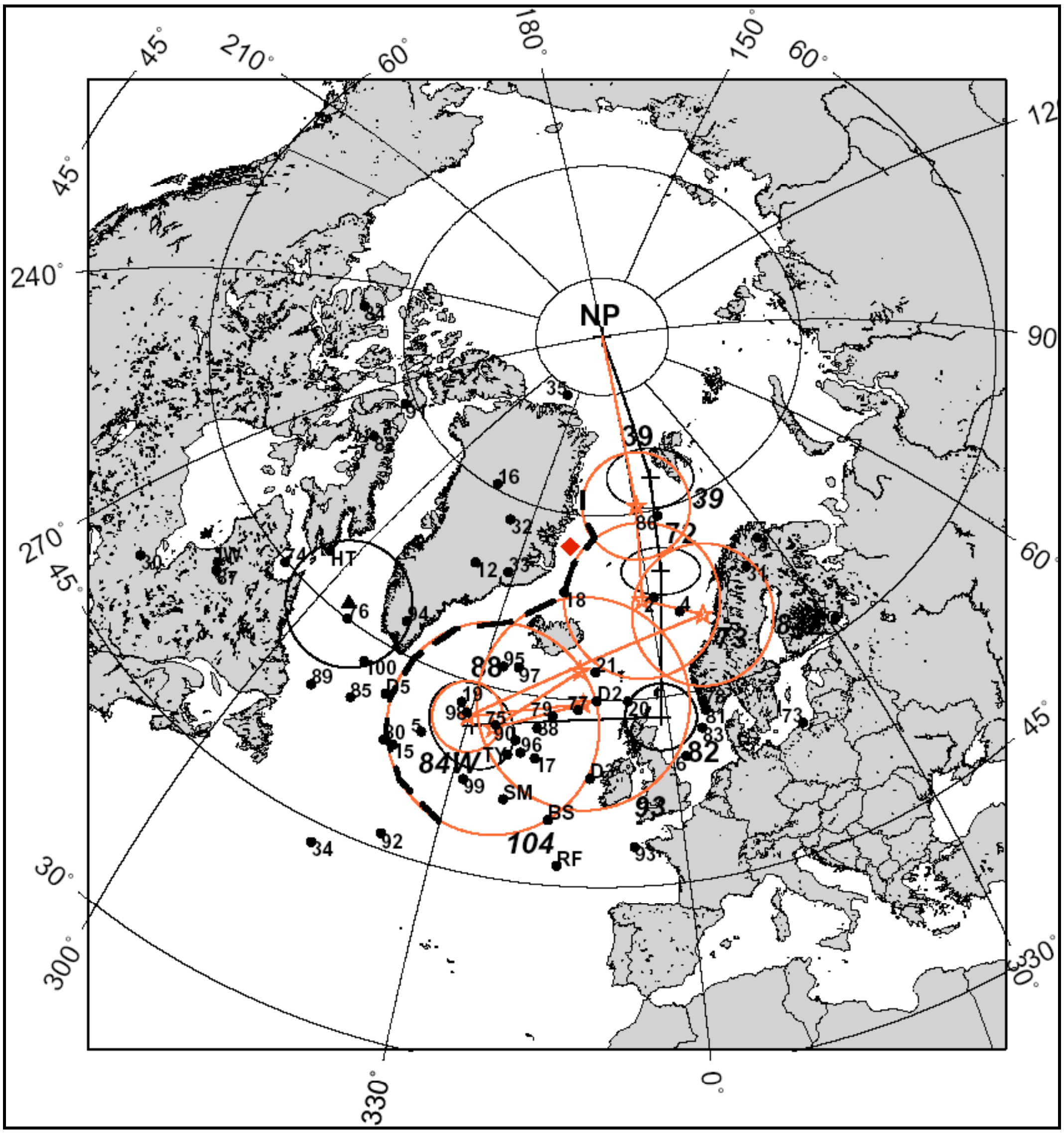

Figure 2: The known Pacific Apparent Polar Wonder Path (Sager and Pringle 1988) shown by the black solid line with its poles locations indicated by crosses. Black circles around them are pole's 95% confidence and big numbers near the circles indicate the age of the pole. The grey solid line is the new Pacific APWP of Sager and Koppers (2000) with its poles indicated by stars. Grey circles around the stars are pole's 95% confidence and big italic numbers near the circles indicate the age of the pole. The diamond indicates the pole for Chron C33r (79-83 Ma) of Sager (2003). Poles of all known seamounts on seafloor older than M1 are shown by solid circles. Seamounts details as in Table 1. The pole indicated by a solid triangle is derived from all seamounts considered to be of Jurassic-Early-Cretaceous age (left of the thick dashed line).

RESULTS

Northward drift amounts of the seamounts that remained were found to vary from 0.7° to 33.3° (Fig. 3). The seamounts were divided into two groups depending on their northward drift amounts: the first group here referred to as **A**, with northward drift amounts less than 15° (shown by solid diamonds), and the other group here referred as **B** with northward drift amounts of 18° and above (shown by solid circles). Because group **A** consists of seamounts with relatively smaller amounts of northward drift than those in group **B**, seamounts in group **A** are relatively older than seamounts in group **B**.

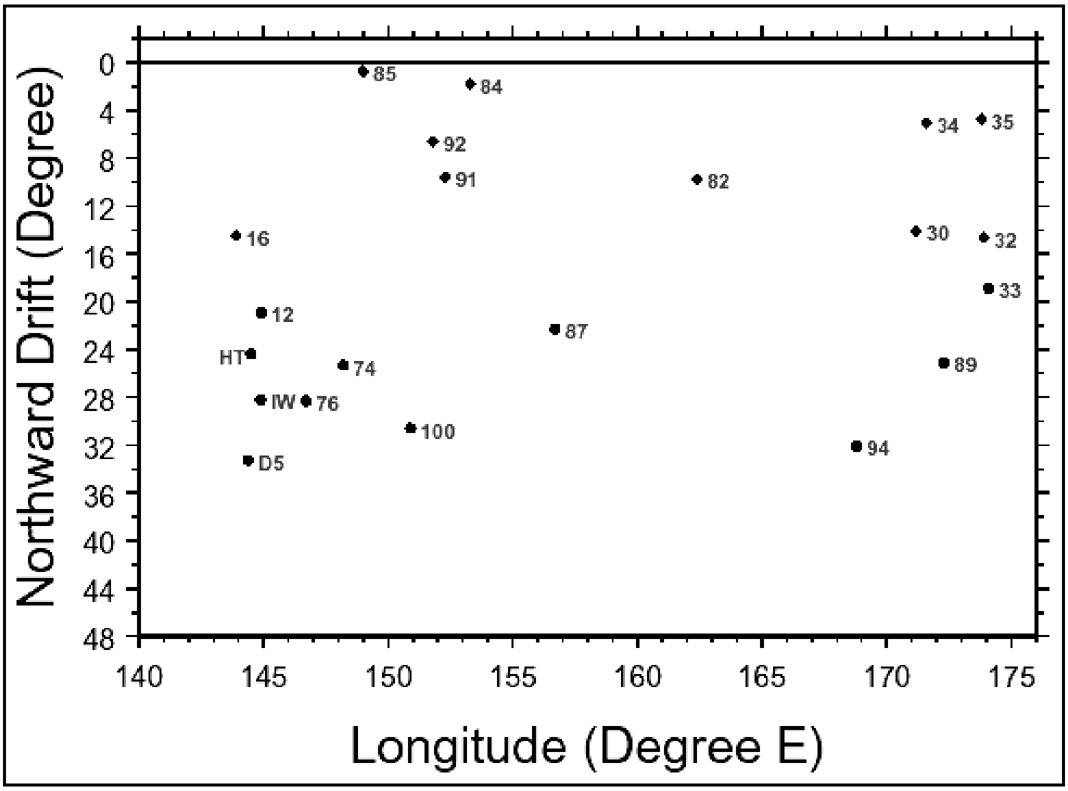

Figure 3: Northward drift of seamounts thought to be Jurassic-Early-Cretaceous in age as isolated in Figure 2 plotted against the seamount's longitudinal location. Seamounts details as in Table 1.

Table 2 shows seamounts within the two groups, **A** and **B**, which have age constrains. Comparing Fig. 3 and Fig. 4 shows that, the poles of Jurassic to Early-Cretaceous seamounts that remained cluster into two groups: the northern cluster between 70°N and 75°N, and the southern cluster between 50°N and 65°N that correspond consistently with groups **A** and **B**, respectively. There are, however, a few exceptions. Poles for seamounts 30, 34, 85 and 92 which belong to group **A** fall within and far to the south of the southern cluster (Fig. 4) instead of falling within the northern cluster as it would be expected based on their northward drift amounts (Fig. 3). Seamounts 34, 85 and 92 are reversely magnetized and the apparently inconsistent location of their poles may be due to effect of significant amounts of magnetic polarity overprint or viscous magnetization of the seamounts (Sager and Pringle 1988, Masalu *et al.* 1993). For seamount 30, the apparently inconsistent location of its pole may be due to poor inversion. The seamounts might also have a different/younger age. These seamounts will not be considered further.

Table 2: Age constraints for Jurassic to Early-Cretaceous seamounts

Group/Pole	ID	Name of seamount	Age (Ma)	Constraints
A	16	Takuyo-Daini	98-144	Guyot topped by Albian - Aptian corals (Matthews *et al*. 1974); Seafloor age is M16 (144 Ma).
	32	Thomas	-162	Thin elastic plate thickness model implies age close to that of seafloor (Watts *et al.* 1980); Seafloor is about M25 (Winterer & Metzler 1984)
	34	Darwin	118-157	Reversed polarity indicates age of M0 (118 Ma) or older; Capped with Albian - Aptian corals (Ladd *et al*. 1974); Seafloor age is M23 (157 Ma).
	85	Campbell	118-161	Reversed polarity indicates age of M0 (118 Ma) or older; Seafloor age is M25 (161 Ma).
	92	Unnamed	118-167	Reversed polarity indicates age of M0 (118 Ma) or older; Seafloor age slightly older than M29 (167 Ma).
B	12	Erimo	104-130	^{40}Ar-^{39}Ar age of 104±9 Ma (Takigami *et al.* 1989); Elastic plate thickness model implies seamount age same as seafloor age, i.e., M8 (130 Ma) (Yamazaki 1988).
	94	Guadaloupe	118-139	Reversed polarity indicates age of M0 (118 Ma) or older; Seafloor age is M13 (139 Ma).
	HT	Hitachi	127-136	Reconstruction to of the flat top of the seamount to sea level give an age of 127 Ma (Masalu *et al*. 2001}; Seafloor age is 136 Ma.
	IW	Iwaki	126-136	Reconstruction to of the flat top of the seamount to sea level give an age of 126 Ma (Masalu *et al*. 2001); Seafloor age is 136 Ma.

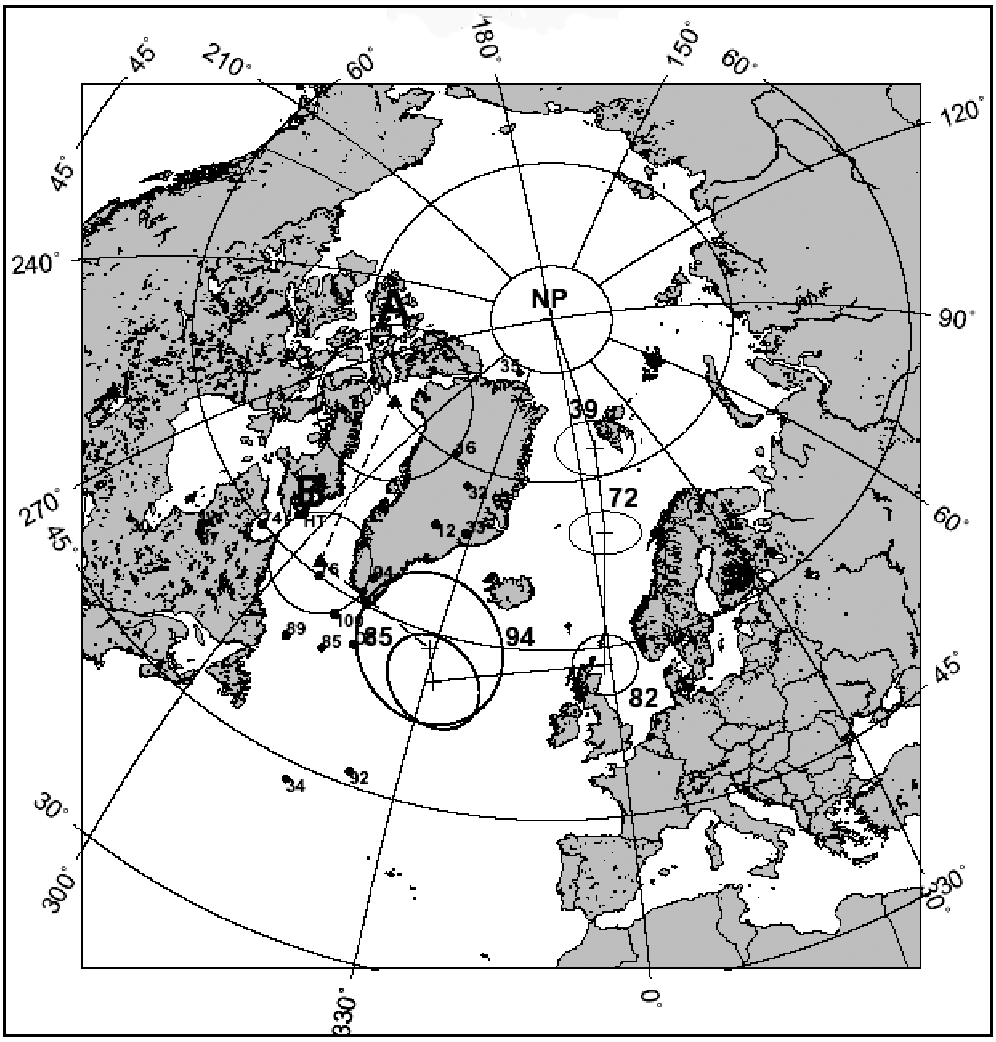

Figure 4: The extended Pacific Apparent Polar Wonder Path (APWP) showing the known part of the APWP of (Sager and Pringle 1988) shown by solid line, crosses to indicate pole locations, circles around them to mark the pole's 95% confidence and the big numbers near the circles to indicate the age of the pole. The extended part of the Pacific Apparent Wonder path is indicated by a dashed line and its poles, **A** and **B** by solid triangles. Poles of all seamounts on seafloor older than M1 that were used to compute pole **A** are indicated by solid diamonds while those used to compute pole **B** are indicated by solid circles. Seamounts details as in Table 1.

The mean pole for each cluster (shown by solid triangle, Fig. 4) was computed. For the northern cluster poles of 16, 32, 35, 82, 84, and 91 seamounts were used. The mean pole for this cluster, pole **A** , is at 75.01°N/287.5°E (α_{95} = 6.9°). To compute the mean pole for the southern cluster, pole **B**, poles of seamounts 12, 33, 74, 76, 87, 89, 94, 100, D5, HT, and IW were used. The obtained mean pole is at

61.0°N/304.7°E (α_{95} = 4.5°). This pole is insignificantly different with the Jurassic to Early-Cretaceous pole obtained by Hildebrand and Parker (1987) which was obtained based on five seamounts residing on Pacific seafloor older than 150 Ma. Seamounts with age constraints (Table 2) were then used to estimate approximate ages of these poles. For pole **B** four seamounts, 12, 94, HT and IW have age constraints (Table 2). All seamounts reside on seafloor with an age less than 140 Ma. A simple mean computed from the mean ages of these seamounts gives a mean age of 127 Ma for pole **B**. For pole **A**, five seamounts have age constraints. All five seamounts as opposed to pole **B**, reside on seafloor older than 140 Ma. A mean pole computed based on the mean ages of the two seamounts, seamounts 16 and 32 that were used in estimation of the pole **A**, gives an age of 142 Ma for pole **A** . The newly computed poles were connected to the known Mid-Cretaceous to Present part of the Pacific APWP (Fig. 4). The results indicate that, the Pacific plate drifted southward during the Jurassic to Early-Cretaceous period.

DISCUSSION

The correspondence between APWPs and hotspot tracks based on available plate motion models is only poorly understood. However, a significant change in the direction of the APWP is often interpreted as an indication of a major shift in plate motion (Gordon *et al*. 1984) and it has been suggested that the two are linked (Sager. and Pringle 1988). For instance, for the Pacific plate, the 82 Ma APWP bend corresponds to the 75 to 70 Ma change in plate motion (Sager and Pringle 1988). Similarly, the 39 Ma APWP bend may correspond to the 47 Ma change in plate motion. Absolute motion of the Pacific plate has recently been studied extensively (Henderson 1985, Engebretson *et al*. 1985, Duncan and Clague 1985). The younger trajectory (0 to ~78 Ma) of the motion of this plate manifested by the Hawaii Emperor Chain (coupled with the availability of reliable dates) is well constrained, while the older trajectory is poorly constrained (Jarrard and Sasajima 1980, Sager and Pringle 1988). The major problem with older trajectory (prior to -80 Ma) is the scarcity of reliable dates and clear hotspot tracks for that period. Consequently, models of absolute motion for the Pacific plate show significant variations for the period prior to about 80 Ma. Nevertheless, advanced research and the availability of many different types of scientific data, have allowed for better models of absolute motion of the Pacific plate.

The correspondence between the Pacific plate absolute motion models and the APWP is compared using the model of absolute motion of Henderson (1985) and the APWP2 of Sager and Pringle (1988) which have been extended by adding the two poles estimated in the present work. Based on the Henderson (1985) model, the Pacific plate shows changes in absolute plate motion direction at about 44Ma, 75 to 80Ma, 95 to 100Ma, and at 130 Ma. These changes of plate motion appear to correspond with changes in direction of the APWP at 39Ma, 82Ma, 85 to 94Ma, and ~127Ma (pole **B**), respectively. The consistency of the timing of the change of the Pacific plate motion at 130Ma and the suggested timing of the change of the APWP based on pole **B** (~127 Ma), suggests that pole B may indeed be about 130 - 127 Ma.

CONCLUSION

An attempt to delineate the Jurassic to Mid-Cretaceous part of the Pacific APWP using a systematic approach which does not depend on availability of reliable dates of paleomagnetic data have been done. Two new poles were computed: pole **A** which is at 75.01°N/287.5°E (α_{95} = 6.9°) and the other pole, **B**, which is at 61.0°N/304.7°E (α_{95} = 4.5°). Pole **B** is relatively younger than pole **A** and it is estimated to be about 130 - 127 Ma. These results indicate that the Pacific plate drifted southward during the Jurassic to Early-Cretaceous period. Changes of plate motion and the APWP appear to correspond. It is hoped that the results presented here will play an important role in future research directions in reconciling models of absolute plate motion and APWPs.

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